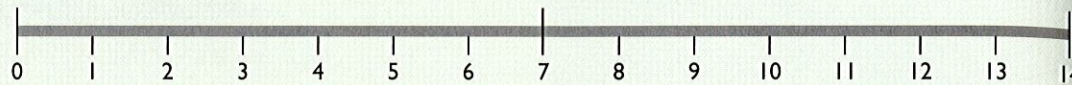


### Analysis

1. Group the substances based on their responses to the cabbage juice.
2. Place the nine substances on a number line like this one, based on the number associated with the color of the universal indicator.



3. Does the number line match the groupings you came up with in Question 1? Would you change your groups in any way?

### Part 2: Treating Indigestion

Calcium carbonate,  $\text{CaCO}_3$ , is a compound used to treat acid indigestion. It is found in over-the-counter antacid tablets.

### Procedure

1. Place a small piece of calcium carbonate into nine wells of the well plate.
2. Add ten drops of each solution to each well. Record your observations.

### Analysis

1. What generalizations can you make about these solutions based on how they responded to calcium carbonate and how they responded to cabbage juice?
2. **Making Sense** List at least four characteristics of the substances you placed on the left side of the number line. List four characteristics of the substances you placed on the right side of the number line.

## LESSON

# 17 Heartburn

## Acids and Bases



### Think About It

Solutions have a wide variety of properties. Acetic acid, or vinegar, is used to flavor salad dressing, while citric acid gives a sour taste to lemon juice and orange juice. Ammonium hydroxide is used to clean windows, and sodium hydroxide is used to open clogged drains. All of these solutions are either acids or bases and can be classified into these categories based on their general properties.



### What are the properties of acids and bases?

To answer this question, you will explore

- 1 Acids and Bases
- 2 Indicators
- 3 The pH Scale

### Exploring the Topic

#### 1 Acids and Bases

#### General Properties

Acids and bases are special categories of solutions. They are extremely useful to us in our everyday lives precisely because of their unique properties. The term *acid* comes from the Latin word *acidus*, which means sour. Many of the sour tastes in our food come from the acids found in those foods. For much of history, the term *alkaline* was used instead of *base*. Bases are found in many household cleaners, from soaps to drain openers to oven cleaners. Bases have a bitter taste, as you may have noticed if you have ever accidentally tasted soap. Bases usually feel slippery to the touch. The slipperiness of bases arises from the fact that they are reacting with the fats in your skin and turning them into soap.

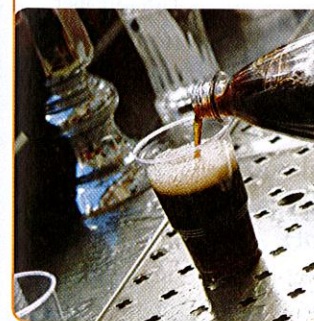
In general, acids and bases are toxic, especially large quantities of concentrated solutions. It is important that acids and bases do not splash on your skin or in your eyes. Acids and bases are both corrosive and can cause a *chemical burn*. A chemical burn is one in which living tissue is damaged.

#### 2 Indicators

Many acidic and basic solutions are colorless and odorless, which can make them difficult to detect by their appearance alone. Because these solutions can be toxic, it is useful to be able to monitor them. Luckily, there are molecular substances called **indicators** that change color when they come into contact with acids and bases. If you add a drop or two of an indicator to an unknown solution, you can tell if you have an acid or a base by the color that results.

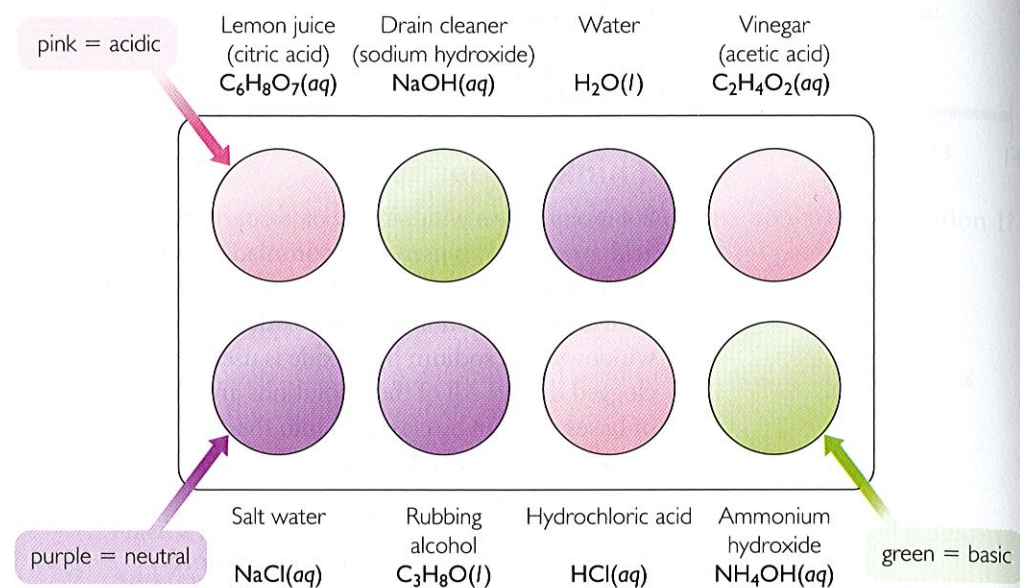
### CONSUMER CONNECTION

Carbonic acid,  $\text{H}_2\text{CO}_3$ , and phosphoric acid,  $\text{H}_3\text{PO}_4$ , are two acids found in carbonated soft drinks. The phosphoric acid acts as a flavoring and a preservative, while the carbonic acid is a byproduct of carbonation.





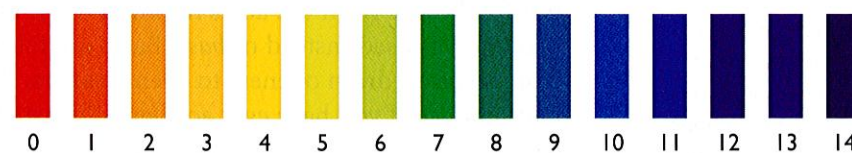
Cabbage juice is a natural acid-base indicator obtained by boiling or grinding up red cabbage. The cabbage juice changes color as it is added to various solutions, as shown in the illustration. Take a moment to look for patterns.



Cabbage juice turns pink when it is in contact with acids, such as citric acid, acetic acid, and hydrochloric acid. It turns green or yellow in contact with bases, such as sodium hydroxide and ammonium hydroxide. And it remains purple or blue in contact with *neutral* substances such as pure water, salt water, and alcohol. Neutral solutions are neither acidic nor basic. So cabbage juice can be used to indicate if a solution is acidic or basic or neither.

### 3 The pH Scale

There are dozens of different types of acid-base indicators, each with a unique color scheme. The colors associated with “universal indicator” are shown in the illustration. Notice that there is a number associated with each color. This number is referred to as the *pH number*, or just as the *pH*.

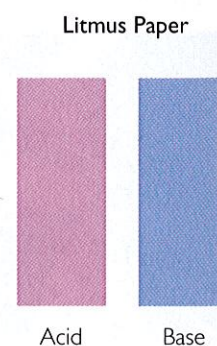


Another way to measure the pH for a solution is with paper coated with indicator, referred to as pH paper.

One common type of pH paper is called litmus paper. Litmus paper turns red in acidic solutions and blue in basic solutions.

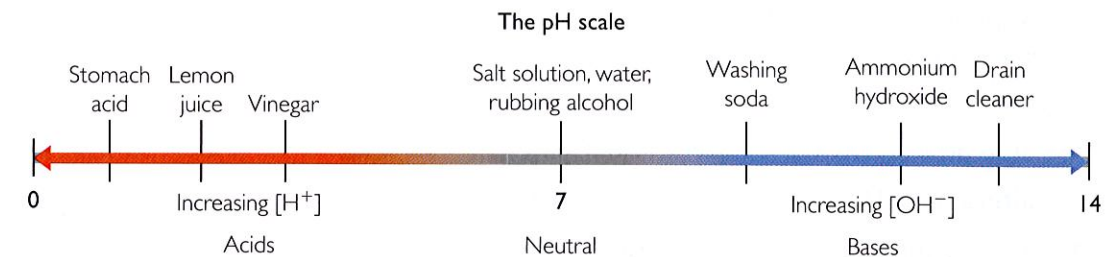
The **pH scale** is a number line that assigns number values from 0 to 14 to acids and bases.

Substances with a pH below 7 at 25 °C are **acids**. Substances with a pH above 7 at 25 °C are **bases**. Substances with a pH at or near 7 at 25 °C are considered neutral. Stomach acid is extremely acidic, with a pH around 1. Lemon juice is



#### HEALTH CONNECTION

Too much acid in the stomach may result in indigestion, heartburn, or ulcers. Antacids are bases that work in the stomach to neutralize the excess acid there. Other remedies work on receptor sites in your body, preventing the secretion of excess acid in the first place.



the next most acidic substance shown here, with a pH near 2.4. The most basic substance shown here is drain cleaner. The substances on either end of the pH scale are potentially more dangerous and more toxic than substances found in the middle of the scale.

#### Key Terms

indicator  
pH scale  
acid  
base

#### Lesson Summary

##### What are the properties of acids and bases?

Acids and bases are special categories of solutions. The sour tastes in our food come from the acids found in those foods. Bases cause the slippery feel of soaps and detergents. Chemical compounds called indicators help chemists to identify the presence of acids and bases in solution. Indicators change color in response to acids and bases. The pH scale is a number scale that assigns values to acids and bases, between 0 and 14. Substances with a pH below 7 at 25 °C are acids. Substances with a pH above 7 at 25 °C are bases. Substances with a pH at or near 7 at 25 °C are neutral.

#### EXERCISES

##### Reading Questions

1. What are some of the observable properties of acids and bases?
2. What is the pH scale?
3. What does it mean to say that a substance has a neutral pH?

##### Reason and Apply

4. **Lab Report** Write a lab report for the Lab: Acids and Bases. In your report, give the title of the experiment, purpose, procedure, observations, analysis, and conclusion.
5. Classify each of the following solutions at 25 °C as acidic or basic based on the information provided.
  - a. lemon juice tastes sour
  - b. a solution of washing soda turns cabbage juice green
  - c. a dilute solution of potassium hydroxide feels slippery
  - d. a sugar solution has a pH of 7
  - e. drain cleaner has a pH of 12

(Title)

**Purpose:** (Explain what you were trying to find out.)

**Procedure:** (List the steps you followed.)

**Observations:** (Describe your observations.)

**Analysis:** (Explain what you observed during the experiment.)

**Conclusion:** (What can you conclude about what you were trying to find out? Provide evidence for your conclusions.)